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Geol Survey

Illinois State Geological Survey 1988-89

Science focusing on issues and trends

Future needs

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Joe Devera, assistant geologist in the Coal Section, points out the tilted strata of the Grand Tower Limestone re-entrant (opening in the rock) attributed to faulting along the Ste. Genevieve Fault Zone.

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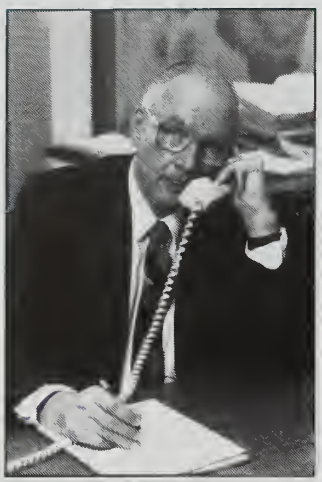
From the Chief



In seeking answers to the multitude of complex environmental- and resource-related issues facing the State of Illinois as well as the nation, earth science research must play a prominent role. This annual report presents some of these major issues and the Illinois State Geological Survey's (ISGS) research and service programs and projects which respond to these concerns. The period covered is Fiscal Year (FY) 1989, extending from July 1, 1988, to June 30, 1989.

Now a division of the Illinois Department of Energy and Natural Resources (ENR), the ISGS was created in 1905 by the Illinois General Assembly. Legislators originally charged the Geological Survey with four primary responsibilities that have remained the backbone of its research and service thrusts over the years. These responsibilities are:

- to study the geologic formations with respect to products such as coal, ores, clays, building stones, cements, materials for use in the construction of roads, gas, mineral and artesian water, and other mineral sources;
- to prepare geologic and other necessary maps to illustrate the resources;
- to prepare reports with illustrations and maps, which include both a general and detailed description of the geologic and mineral resources;
- to consider other scientific and economic questions of value to the people of Illinois.

The ISGS serves both the educational and economic needs of the state, performing scientific research, providing services, and collecting data that help strengthen the state's economy and improve the quality of life of Illinois' citizens.

With the passing years, Survey researchers have applied more sophisticated scientific techniques and analytical instruments as well as computerized data bases to the originally-mandated activities and to the additional, more environmentally-oriented concerns. Newer endeavors focus on the environment, the wise use and protection of our land and its finite resources, like groundwater.

This publication has been prepared especially for the general public. Should you wish more comprehensive, technical information, I invite you to request a copy of the Survey's scientific annual report.

Morris W. Leighton

Issues and Trends

Illinois faces serious issues concerning its water, land, energy and mineral resources. Can it ensure an adequate supply of these resources? Are these resources being properly used? Are other uses possible that would help stimulate the economy?

Environmental issues related to the management and protection of these resources abound—issues that involve public safety, health and recreation; agriculture; and the state's infrastructure. Is groundwater contamination a problem? If so, where? How do we protect our groundwater? How should we manage wastes to avoid contamination? How do we produce clean coal? Can natural or man-caused hazards be prevented or mitigated? Can we use Earth's processes to our advantage to improve conditions or enhance the quality of life?

Responses to these and similar questions depend on continually increasing knowledge and understanding of the structure, resources and dynamics of the Earth—the geology of this state. The public and its governmental officials require this type of scientific information to make informed decisions about the wise use of the finite and precious resources—decisions which will affect the standard of living, economic growth, and security of Illinois' residents and can have an impact on the nation as well. To this end, the Illinois State Geological Survey (ISGS), a division of the Department of Energy and Natural Resources (ENR), is mandated to provide the scientific knowledge to answer such questions.

Research investigations and service efforts at the ISGS address the state's issues or anticipated needs and take trends into account. Such trends include a greater concern for the environment and quality of life: the increasing need for groundwater protection; and the increasing problems of contaminants, pollutants, toxic compounds and elements, and radioactive materials....

Continuing shortages in the domestic crude oil supply and liquid hydrocarbons for transportation, coupled with the increasing reliance on foreign resources, step up risks to national security.... Increasing needs for commercially-viable energy options along with energy conservation garner attention....

The increasing dependence on foreign countries for critical and strategic minerals also adds a greater risk to national security.... For construction purposes, the increasing demands for quality aggregates, sands and gravels command the Geological Survey's concern....

And from a scientific standpoint, the increasing need to test hypotheses through field studies, drilling, and seismic investigations as well as to scale-up pilot plant operations to test concepts are essential.... Recognition is also given to the greater importance to add to, update and upgrade data bases; to speed information dissemination related to earth science; and to transfer technology to solve earth-related problems.

Members of the Intergovernmental Solid Waste Disposal Association's board and its citizens' advisory board listen to Don McKay, geologist and head of the Computer Research and Services Section, describe earth materials they will deal with in siting a new landfill in Champaign County. Their field trip included gravel pits, outcrops and a look at cores in the Geological Samples Library.

Scientific Efforts at the ISGS on Behalf of the Issues

Protection of Water Resources

Water, a very vulnerable resource, is a necessity for all living things. Being essential to life itself, water, whether its source is an aquifer, reservoir, lake or stream, must be protected from contamination. Thus, the ISGS is very actively involved in meeting mandates of the Illinois Groundwater Protection Act (IGPA) by conducting pertinent mapping, assessments, monitoring and technical assistance programs in support of protection and preservation of groundwater quality as well as management of groundwater resources. To facilitate these tasks, the Survey has been involved in several programs that provide information to state and county agencies that begin the process of groundwater protection in the state. To date, Survey scientists have focused on assisting state agencies in targeting resources to areas of critical need.

A major effort last year was the development of a state-wide reconnaissance map showing potential recharge to aquifers (or potential for contamination of aquifers from surface sources of waste). Recharge areas are ranked primarily according to the relative potential of geologic materials to transmit water, the depth to and importance of aquifers (major aquifers versus non-major aquifers) as groundwater suppliers, and to a lesser degree infiltration rates determined according to soil association hydrologic ratings. This map's information has been combined with data supplied by the Illinois State Water Survey (SWS) on the distribution of potential sources of contamination. The Illinois Environmental Protection Agency (IEPA) and Survey scientists will use this information to help identify areas having a high potential for groundwater contamination, to establish groundwater protection planning regions, and to target areas requiring more detailed geologic mapping and studies.

Don Keefer, left, staff geologist, and Dick Berg, geologist and head of the Groundwater Protection Section, discuss a state-wide reconnaissance map showing potential recharge to aquifers or potential for contamination of aquifers from surface sources of waste.

In a cooperative effort, the ISGS and the SWS have been working on programs to evaluate the impact of agricultural chemicals (pesticides and nitrates) on groundwater, particularly in rural areas where they are most intensively used. Together with the Illinois Department of Agriculture (IDOA), the Surveys have begun a pilot study on agricultural chemicals in rural private wells in five township-sized areas of differing hydrogeologic conditions in Mason, Kankakee, Livingston, Piatt and Effingham counties. This study will implement methods, developed by the U.S. Environmental Protection Agency (USEPA), to analyze for pesticides and nitrates; test protocols for the characterization of well sites, collection of samples, and management of data; and evaluate criteria used in estimating the potential for contamination of rural, private water wells.

Monitoring the persistence and mobility of pesticides in four loessial (wind-blown silt) soils indicated that the greatest mass of pesticide residues was retained in the upper 20 centimeters of the soils, with trace levels detected below 20 centimeters in the spring following application. The most important result of this study was evidence for preferential flow.

A series of state-wide maps were compiled for the Hazardous Waste Research and Information Center (HWRIC) showing the density of current waste generation and disposal practices. Using the Illinois Geographic Information System (IGIS), those maps were overlaid with another map showing the potential for contamination of aquifers in Illinois. These composite maps identify areas where the density of current waste activities may be a significant threat to groundwater resources.

Computer modelling of geological settings common to Illinois indicates that it is possible to quantitatively rank them for potential groundwater contamination from migration of landfill leachate. This research also included evaluation of the Illinois Pollution Control Board's (IPCB) proposed regulatory compliance distance of 100 feet for maximum leachate migration from municipal landfills. The regionally-mapped scenarios suggest that geologic conditions over about 50 percent of the state are favorable to meet the suggested compliance distance of 100 feet or less for contaminant migration from landfills over a 100-year period. More detailed mapping and bedrock fracture considerations may further limit the areas.

Wise Use of Land

Land and its wise use calls for current and more detailed cartographic and geographic information, particularly as the surface of land changes from natural causes and human activities. Because conflicting uses and demands for land are often unavoidable, planners and officials must weigh the benefits these potential uses will have against their potential impacts. For the effective management of land resources, topographic maps, geologic maps, land-use maps, computerized cartographic data, and aerial images and data are essential tools for identifying, locating, measuring, and comparing natural and man-made features, and providing information needed to assess values and help determine sequential land use.

Identifying land resources and uses as well as providing maps for regional screening purposes are consequential to prudent decision making regarding land use, especially under the constraints of rapidly diminishing land available for development. For more than 25 years, the ISGS has been mapping complex geologic and resource information and presenting such data in a form easily useable by municipal, county and regional officials, planners and engineers. In these geology-for-planning studies, earth materials are mapped in great detail and then interpreted for a variety of land uses. With this information, planners, contractors and others can take advantage of those earth materials capable of a specific use while avoiding those materials in which problems may exist.

These studies are done in cooperation with other state, regional and local governmental agencies. The latter provide definitive statements of land-use issues, resource needs and planning objectives. Generally taking two-to-three years of full-time effort to complete a county, these studies commonly require some exploratory drilling and other sampling and field studies to fill gaps in data after existing geologic information for the county is gathered. Thereafter,

Ardith Hansel, geologist in the Quaternary Framework Section, discusses glacial deposits.

from this combined information, a series of maps are prepared to classify areas of the county according to such factors as susceptibility for contamination of groundwater, capability for installation of septic systems, potential for groundwater resources, potential for sand and gravel deposits useful for construction aggregates, and foundation conditions for construction.

Geology-for-planning studies help counties and municipalities face increasing pressures in making land-use decisions by providing information on specific areas or sites for specific uses. The computerized IGIS allows the development of special interpretive maps to meet the needs of a particular community or region after the necessary basic data have been gathered and entered into the system. With the basic data available, ISGS scientists can continue to interpret the information and give advice long after the original study's completion. By using detailed geologic information while making decisions, county officials, citizens and industries can avoid improper land uses that could cost millions of dollars to correct later.

A demonstration of the value of this approach is under way in Kane County. The ISGS has begun this comprehensive study to help community land-use planners determine areas of the county where potential contamination of groundwater resources from municipal landfills and land application of waste water will be minimized. The study will also identify areas of the county having the highest potential for potable groundwater resources. Preliminary work for the Kane County project began as a direct result of information developed during the siting study completed for the Superconducting Super Collider (SSC). As part of the SSC wrap-up tasks, both geologic and interpretive maps (including aggregate resource potential, land application of waste water, and aquifer distribution) will be produced from data developed in association with SSC investigations. A three-phase proposal to continue this work during FY90 was submitted to the Kane County Board so that a comprehensive and complete report can be prepared for inclusion in the county's revised master plan.

Quaternary investigations (study of geologic deposits made during glaciation) are also providing helpful information for decisions on wise land use. The Quaternary Framework Studies Section is establishing the three-dimensional framework of glacial deposits and other surficial materials that overlie bedrock throughout the state. This effort will expand knowledge of the hydrogeologic, geotechnical, and geological properties of near-surface units and will enable predictions to be made of the geologic capacity of our surroundings to sustain and encourage economic development.

In a pilot study, scientists are compiling a catalog of key stratigraphic control points for the Quaternary in northern Illinois and classifying the key control points by the quality and quantity of data collected, a step in determining what the ISGS knows and what it does not know about a given area. Classic glacigenic sections in northeastern Illinois are being re-examined. Increased knowledge of facies associations, their genesis and geometries makes it easier to predict subsurface relationships that bear on groundwater resources, land-use planning, landfill siting, and engineering properties for construction.

Waste management practices and technology continue to attract Survey effort and interest. Illinois ranks second in the United States in the production of hazardous wastes, and much of that waste is generated at factories and other

facilities in northeastern Illinois. Consequently, proper handling and disposal of wastes is of particular concern in that part of the state but necessary throughout Illinois. The legacy of past practices of waste disposal includes numerous sites that have adversely affected the environment. The problems are made even more acute because of the strong competition among various uses for the available land in the region.

Since the early 1960s, the ISGS has conducted field and laboratory studies on such subjects as groundwater flow and transport of groundwater contaminants, chemical interaction of contaminants with earth materials, and improvements in the construction of landfill trench covers and liners. The Survey's waste management research and service work has two major thrusts: site-screening and characterization studies for proposed waste disposal facilities, and more generic studies that relate to the movement of chemicals in the subsurface and the ability to monitor this movement.

On the basis of these research programs, the ISGS provides geological information about waste disposal problems for other governmental agencies, industry and the public. Recent studies have emphasized the proper siting of future waste disposal facilities. The Survey is also studying landfill covers and liners to improve performance of engineered waste facilities.

The ISGS, in cooperation with the SWS, has continued to provide support to the Illinois Department of Nuclear Safety (DNS) and its primary contractor, Battelle Memorial Institute, for site-characterization efforts for a low-level radioactive waste (LLRW) disposal facility in Clark and Wayne counties. Elements to adequately characterize the candidate sites have been developed in a collaborative effort between Battelle and the Surveys. Two reports, issued in final form in January 1989, summarize criteria and geologic considerations for siting a low-level radioactive waste facility and present a recommended methodology for site selection. The suggested procedures for conducting LLRW investigations incorporate three steps: regional screening, area screening and site characterization.

In cooperation with ENR's Office of Solid Waste and Renewable Resources, Survey scientists met with Champaign, Crawford and Madison county officials to assist in the design of a screening approach to site landfills. Technical assistance is being provided to McHenry and Champaign counties in locating geologically-suitable sites for landfills.

Waste management activities have been extended to study the disposal or re-use of the waste solids from fine-coal cleaning processes. In addition, information is being provided to guide the disposal of oil-field brines by underground injection.

A new Hydrogeology Research Laboratory was formed in December 1988 to focus research efforts on the movement of fluids and chemicals through earth materials with very low permeability such as the compacted shales or clays used in liners and trench covers of landfills. The experiments with a field-scale clay liner are recognized as part of this effort.

Importance of Proper Siting

Locating facilities and the infrastructure properly, another important issue facing the state as well as the nation, also requires geotechnical information and maps for making siting decisions. Deciding where to build new roads and power lines, where to lay pipelines, or where to place new industrial, research or housing complexes requires an understanding of the engineering properties of rocks and soils, the slope of the land,

and the potential for natural or man-caused hazards.

A two-year geotechnical site investigation for Argonne National Laboratory's 7 GeV Advanced Photon Source concluded that no problems exist that would preclude construction and successful operation of this facility as long as normal engineering precautions are taken. Information about the sedimentology, hydrogeology, and engineering geology of the site will provide a sound basis for engineering design to meet the facility's stringent requirements against vibrations.

The record of water-level fluctuations from a monitoring well at Argonne National Laboratory's site for the 7GeV Advanced Photon Source is retrieved by Myrna Killey and Brian Trask, both associate geologists in the Environmental Studies and Assessment Section.

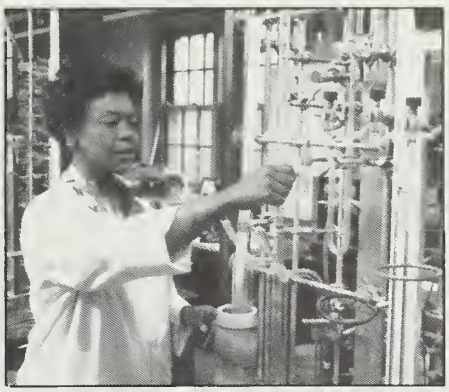
And finally, under a contract with the Illinois Department of Transportation (IDOT), all IDOT property or that which is to be acquired for improvements to the infrastructure is being investigated by ISGS staff for the potential of containing natural or man-caused geological hazards. Such preliminary site assessments include the investigation of current and past land uses through a review of historical documents and data from computerized geographic information systems; on-site inspections; limited field analyses of soil, water and air; and a report, summarizing this information in addition to available geologic, hydrogeologic, and other background data.

Protection of Health, Safety, Recreational Properties

Consider the fact that natural events annually threaten lives and cause millions of dollars in damage to structures and property in Illinois. Public health and safety and recreational properties can be protected and enhanced when earth-science information is used to delineate areas prone to earthquakes, landslides, mine-subsidence, floods or erosion; assess risks to people and property; and mitigate or avoid damage. In fact, earth science can aid in land-use planning, engineering design, and emergency preparedness by helping to assess the potential for hazardous events and their possible severity so that structures can be located and constructed more advantageously.

Among the public health and safety issues studied this past year were radon, landslides, risks from earthquakes and their effects, coastal erosion, and sources of leaking natural gas.

Survey staff continued to provide guidance and technical assistance on radon. Radon measurements conducted in 12 University of Illinois buildings found no unsafe levels.... Concentrations of radon in natural gas from 12 different producing gas fields in the state presented no health risk to consumers when used in conventional applications.... The Survey has acquired data on indoor radon from private companies and the DNS with approximately 16,000 measurements, locations and dates of measurements included in the data set. Scientists are plotting the data by zip codes using the IGIS with the support of the Survey's Computer Research and Services Section.



Eltricia McMillion, technical assistant in the Isotope Geochemistry Laboratory, operates a vacuum system that prepares geochemical samples for isotopic analysis.

Looking into the landslides at Chester, scientists determined excess water as the cause of unstable slopes. Water samples were tested to determine the possible source of water (either a shallow groundwater aquifer or a broken city water line) at a slope near the stadium of Chester's high school. Chemical analyses showed high chloride and fluoride concentrations, leading to the conclusion that the water source was probably a broken water line.

In response to the many inquiries concerning seismic risk in the state, the ISGS has examined the historical record of seismicity in detail and documented that the New Madrid Seismic Zone in Missouri is the greatest source of seismic risk in Illinois, particularly in the southern portion of the state. The Survey is also preparing a video on epicenters of Illinois' earthquakes that occurred between 1795 and 1988. In addition, scientists are working with the U.S. Geological Survey (USGS) to determine suitable locations for seismic stations in Illinois.

Fingerprinting samples of natural gas to determine their origin is another of the Survey's services directed toward public safety. At the request of the DuPage County Forest Preserve District, gas samples were collected from selected monitoring wells located around a landfill to determine if the gas present were coming from the landfill or from another source. Stable isotopic and radiocarbon analyses of the samples indicated the gas originated in the landfill. In another instance, the Survey responded to a request from the Springfield Fire Department to determine the source of high concentrations of methane found in the city's sewer system. Several possible sources were considered: gas generated by the bacterial decomposition of organic material (normal sewer gas), gas from a nearby abandoned coal mine, or leakage from a natural gas pipeline. Analyses of samples indicated that it was pipeline gas.

Coastal erosion has had detrimental effects on public safety as well as property, including recreational areas. In 1986, Lake Michigan rose to record levels, causing great damage over much of the Illinois shore. From November 1986 through the summer of 1988, however, the Great Lakes watershed experienced the driest period of the past 85 years, and lake levels fell more than three feet. Rainfall since then has returned to normal, and lake levels had risen to average levels by August 1989. The respite from high levels gives only a measure of relief, however, because areas of shore have been so weakened that major storms, even at present water levels, cause damage. Consequently, agencies and private owners have viewed these years as a time to rebuild for the next cycle of high levels.

The Chicago lake front has suffered the most. Surveys using sidescan sonar images and visual inspection showed that the city's massive revetments, well beyond their design life and without maintenance for years, are in a state of disrepair and decay. Public agencies face a rebuilding program costing many millions of dollars in the near future. Data compiled by ISGS scientists indicated that, of approximately 25 miles of Chicago shore, 11 miles are in need of immediate action; an additional five miles will require attention in the near future. Beaches are being rebuilt as funds allow. More than three miles of new breakwater are needed. The city and park district have spent more than $3 million to repair beaches, correct safety hazards, secure transportation, and protect the water supply. The state and federal governments have spent similarly large sums.

On the shore north of Chicago, communities have spent an equal amount,

while private owners, in 122 projects, have conducted an intensive shore-protection program, investing more than $2 million in shore-protection structures, yet dozens of properties remain unstable and damaged. Although numerous beaches have emerged as lake levels have fallen, they consist of a veneer of fine-grained materials that may easily be swept off shore.

Municipal response to the increasing call for recreational beaches has resulted in the development of designer beach-park areas. Lake Forest, Highland Park and Chicago have completed or have considered such facilities. Waukegan recently expanded its harbor and plans additional expansion. The State of Illinois is completing a $37-million harbor facility near the Wisconsin state line.

All of these construction activities require scientific and engineering data, taking decades to acquire. The ISGS conducts research to develop and gather technical information in response to immediate lake-shore needs and in anticipation of long-term trends and future problems.

Coastal geologist Michael Chrzastowski, left, and a colleague from the U.S. Geological Survey extract a sediment sample from the bottom of Lake Michigan near Evanston.

The scientific and engineering data are used to advise lake-shore communities and riparian landowners, the U.S. Army Corps of Engineers, the Illinois Departments of Transportation and Conservation, the Great Lakes Commission, the Chicago Park District, the Chicago Department of Planning as well as other governmental agencies, engineering firms and consultants seeking assistance with shoreline mitigation and development. Project staff members make numerous site visits in response to public requests and present public information conferences, interviews and programs.

During the past year, detailed information has been obtained on bottom morphology, shore development and erosion rates in Lake Michigan coastal areas from wide-ranging studies that included bathymetric mapping, sonar surveys, littoral drift investigations, and compilations of histories of shore erosion, lake levels and sedimentation—efforts jointly conducted by the ISGS and the USGS. The R.V. Neptune, under lease to the USGS, measured bathymetry, conducted shallow geophysical soundings, took sidescan sonar images, and collected sediment samples along five transects in Illinois.

Through a $300,000 grant from the USGS and in cooperation with that federal agency, a sidescan sonar survey was completed along the entire Chicago lake front, complementing the preliminary survey carried out over a portion of the lake front in 1987. The surveys are proving useful in documenting the nature of the damaged shoreline-protection structures and in helping to identify the responsible processes. The sidescan sonar imaging also covered the Indiana shoals, on the Lake Michigan extension of the Illinois-Indiana line, and identified major commercial sand deposits, which could be used for beach replenishment.

The recent history of the Illinois shore of Lake Michigan and an inventory of all properties along the Illinois shoreline are being documented in a series of aerial photographs, digitized maps, and a revised coastal atlas. A draft of the atlas is being reviewed by selected governmental agencies and municipal authorities. Computer-generated maps of the Illinois shoreline for the periods 1872 and 1988 were provided to the USGS and the National Oceanic and Atmospheric Administration (NOAA) researchers who are determining average recession rates of the five Great Lakes.

One-foot-interval contour maps have been generated from a 1988 lake-bottom topographic survey. These maps will serve as base-line data to study the future impacts of the installation of North Point Marina on beach and lake-bottom erosion and deposition.

Scientists of the ISGS also are studying problems caused by chemical contamination of Lake Michigan's harbors and bottom sediments. Average concentrations of eight metals of environmental interest have been compared among sediment samples from various locations in or adjacent to Lake Michigan. Included in the comparison were samples from Lake Calumet, Calumet Harbor, Little Calumet River, Lake Michigan, Waukegan Harbor, Cal-Sag Channel and Wolf Lake. The results showed that Waukegan Harbor sediments contain approximately 1.5 times more cadmium and chromium, 13 times more sodium and, excluding the Cal-Sag Channel, 1.5 times more zinc than other nearby water systems. Fish from Waukegan Harbor and surrounding areas tested higher than fish collected from Lake Superior waters in lead (28 times), zinc (three times), chromium (37 times) and copper (three times), but contained an order of magnitude less mercury and 40 percent less cadmium.

In a joint study with the Illinois Natural History Survey (INHS), scientists assessed the environmental significance of contaminants in Indiana Harbor and Canal (IHC) on the biota in the harbor and adjacent Lake Michigan. They analyzed 13 sediment samples and 42 biological composites (fish, crayfish, periphyton and plankton) for total polychlorinated biphenyls (PCBs); total polycyclic aromatics (PAHs); major, minor and trace elements; and, where applicable, total phenols, cyanide, ammonia, percent lipid, ash and organic carbon. Concentrations of (PCBs) in fish from Indiana Harbor ranged from 15 parts per billion to 7.9 parts per million. The concentrations are generally higher than in Waukegan Harbor fish. Sediments from IHC were also found to contain higher quantities of cadmium (six times), chromium (six times), zinc (six times), iron (three times), nickel (three times) and lead (two times) as any other nearby water system, excluding the Cal-Sag Channel. Harbor sediments are heavily polluted with cadmium, chromium, copper, iron, manganese, nickel, lead and zinc. While concentrations of metals and organics decrease toward the mouth of the harbor, contaminated sediments have been carried into the lake from the harbor.

Link between Economy, Environment

Earth-science related issues surrounding Illinois' huge agricultural and coal mining industries demonstrate the important link between maintaining the state's economy and protecting its environment. The Illinois Mine Subsidence Research Program (IMSRP) was established in 1985 to develop guidelines for underground mining methods to maximize coal extraction while preserving the agricultural productivity of farmland in the state.

Brenda Mehnert, geological engineer in the Earth Hazards/Engineering Geology Section, monitors damage in a cable installed to measure subsidence in overburden.

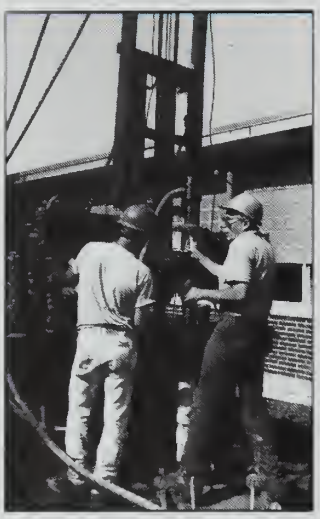
This coordinated research program includes projects that deal with both planned and unplanned mine subsidence. Projects are designed to provide data for the development of reliable subsidence and mine-stability prediction techniques for longwall, high-extraction retreat, and room-and-pillar mining methods. Collaborative research efforts have been developed in the state among Southern Illinois University-Carbondale, the University of Illinois at Urbana-Champaign, Northern Illinois University, the ISGS and the U.S. Bureau of Mines (USBM) in order to involve established experts in the field.

The IMSRP has been charged with addressing a number of scientific, economic and social concerns expressed by the coal industry, Illinois farmers through the Illinois Farm Bureau (IFB) and the Illinois Department of Mines and Minerals, which regulates the coal industry. One major goal is to assist the Illinois coal industry in becoming more competitive in the market place. Recent studies have shown that Illinois coal is not only losing markets because of its high-sulfur content but also because of its high delivered price. Increased productivity through longwall mining provides a vital economic boost by reducing mining costs per ton. Also, these high-extraction methods utilize less wasteful, more efficient means of mining than the room-and-pillar method, which leaves considerable coal behind. Recommendations drawn from IMSRP rock characterization studies of mine floors and pillars will allow development of environmentally-sound, yet more productive operations for all mine designs.

On the other hand, subsidence over high-extraction underground coal mines or high partial-extraction areas may affect farmland. To assess this potential problem, corn-yield reduction in subsided areas was compared statistically with corn from unmined areas under the same farm management. The average reduction in corn yield on unmitigated land was found to be 4.7 percent over longwall mines and 1.8 percent over high-extraction retreat mines. From this study, important relationships were identified between crop yield and soil slope and type. Agronomists continue to assess the effectiveness of repair methods on land where planned subsidence has taken place. Preliminary results indicate no significant difference in yields between control and mitigated sites in 1988 for corn and soybeans.

Subsidence may also have an impact on water resources. To examine this possibility, groundwater levels are being monitored before, during and after subsidence at several active mining locations. Water levels in test wells are monitored continuously by electronic records to ensure accurate, timely measurements. In addition, water chemistry and quality are being tested and evaluated. Preliminary results over several deep longwall panels show that water wells in near-surface glacial materials were unaffected by subsidence, but water levels in bedrock wells were temporarily lowered, recovering several months after mining.

Analysis of data from on-site strength testing of floor materials in Illinois room-and-pillar mines is leading to models that can predict subsidence movements based on material properties. Investigations of changes in the characteristics of overburden bedrock, soil and hydrology caused by subsidence at a third longwall panel are continuing, and the current procedures used by coal operators to correct subsidence problems on the surface are being evaluated. The ISGS functions as a clearinghouse for information on mine subsidence research.



Tim Young, left, ISGS drill rig operator, converses with Paul DuMontelle, engineering geologist and assistant branch chief, Environmental Geology and Geochemistry Branch, about the hole being drilled through which instrumentation was placed to measure subsidence occurring at Dorris Elementary School, Collinsville.

Coal, water and farmland are valuable resources and important to the state's economy. Guidelines being developed by IMSRP will both enhance coal utilization and protect these other resources.

Impact of Energy Resources

Energy resources, which include both coal and oil and gas, have a significant impact on the state's and the nation's economic well being. The value of fossil fuel production (both coal and oil) decreased significantly in Illinois during 1988. During 1988, nuclear energy surpassed coal as the prime fuel for the generation of electricity in the state. Coal production amounted to 56.6 million tons compared to 60.8 million tons in 1987.

Illinois leads the nation in resources of bituminous coal that have a high potential for development. In fact, the state has approximately 50 billion tons of such coal that is high in quality, except for its high-sulfur content. Continued use of Illinois coal by utilities, its major market, is threatened by proposed acid-rain legislation to restrict sulfur emissions. The closing of mines, thereby shelving this valuable resource, could have serious effects on national security in times of energy shortage.

Decreasing emissions of sulfur dioxide by 90 percent from burning Illinois coal, a possible requirement of proposed legislation, will not be an easy task, especially in the short time likely available before implementation. Fortunately, research programs seeking ways to decrease these emissions are well established at the ISGS. These studies include

In the newly remodeled microbial geochemistry laboratory, Suchada Broeren, assistant geochemist, checks an anaerobic culture from a soil sample for bacterial growth. The culture is maintained in an oxygen-free environment provided by the anaerobic hood.

precombustion cleaning methods to decrease the sulfur and mineral matter content, post-combustion cleaning to more economically remove sulfur dioxide from combustion gases, and research to remove other deleterious elements such as chlorine, nitrogen and ash-forming minerals from coal.

About half the sulfur in Illinois coal is chemically bound within the organic particles called macerals, which comprise most coal material. A large part of this organically-bound sulfur needs to be removed to produce compliance coal. Because standard procedures are unsuitable for determining the organic sulfur distribution within the macerals, the ISGS adapted a procedure to make these measurements with the aid of an optical microscope and a scanning electron microscope equipped with an energy dispersive X-ray analyzer. Knowledge concerning the distribution of organic sulfur in macerals perhaps can be utilized to improve various desulfurization processes.

Assistant geologist Dan Adomaitis, of the Geochemistry Section, puts a thermocouple in a new tube furnace that will be used in the carbon monoxide-ethanol coal desulfurization project.

Design goals of a continuous-feed, gas-flow reactor (CFU) have been established as part of a desulfurization project using carbon monoxide (CO) and ethanol. The CFU will be used to demonstrate a combined three-step technology that removes both inorganic and organic forms of sulfur from high-sulfur coals using consecutive CO and ethanol treatments. In furtherance of these efforts, a first-phase contractual agreement was negotiated and experimental work started at the University of North Dakota's Energy and Mineral Resources Center for adapting the CO/ethanol technology to fluidized-bed reactors. In addition, the concept of a one-step CO/ethanol process was recently patented.

The Survey has been investigating advanced froth flotation of fine coal as a

Senior staff minerals engineer Henry Ehrlinger adjusts the Diester Column Flotation apparatus in which the Survey's flotation reagents are being tested for not only efficiency but also economy in the removal of pyrite and ash from Illinois' high sulfur coals. Results will be compared with those from a conventional flotation machine.

precombustion desulfurization method. The method developed can be used to clean finely ground coal or to recover coal from the fine waste stream of a preparation plant. The most cost-effective reagent package for waste streams at preparation plants is one using alcohol/kerosene with small dosages of surfactant added to increase flotation rates. For plant-washed samples, alcohol/surfactant systems have been found to be an effective alternative to commonly used alcohol/kerosene systems. Comparison of results for given reagent systems used in subaeration cells and in a column showed greater ash and pyrite removal in the column than in the subaeration cells.

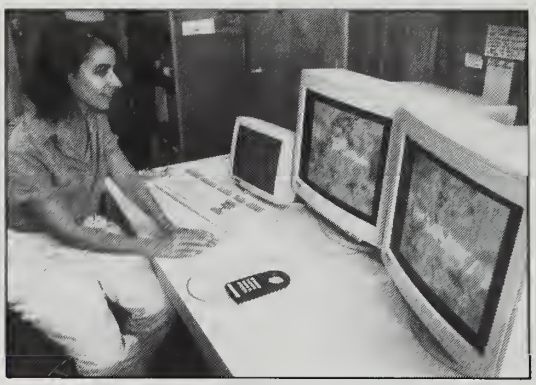
Dave Moran, chemical engineer in the Minerals Engineering Section, monitors a spray dryer producing a high-surface-area hydrated lime used as a sorbent for sulfur-dioxide emissions from coal-fired combustors.

Engineers at the Geological Survey have developed a proprietary process for producing high-surface-area hydrated lime for use as a sorbent for sulfur-dioxide emissions. Pilot-scale tests performed by Consolidation Coal Company, KVB Inc. and the USEPA exhibited superior performance for the ISGS hydrate compared to commercially-available calcium hydroxide sorbents. The results indicate that the ISGS hydrate is the most effective sorbent tested to date for controlling sulfur-dioxide emissions from coal-fired combustors.

The high chlorine content of some Illinois coals makes them unsuitable for use in power plants with flue-gas scrubbers because the chlorine corrodes the scrubber equipment. By wet-grinding coal to -200 mesh and then leaching the resulting filter cake of ground coal with hot water, ISGS researchers reduced the chlorine content of the coal by 50 percent.

A large problem in coal research has been the inability to obtain reliable duplicate coal samples. Often researchers observe an interesting and potentially useful reaction in coal only to be hampered in repeating the observation because of deterioration of the coal sample and lack of a source for a similar sample. In addition, comparison of results from laboratory to laboratory has always been questionable because of the variability of samples. To overcome these problems, the Survey established the Illinois Basin Coal Sample Program to provide identical samples of representative coals to researchers throughout the world. These coal samples have become widely used and bring Illinois a large quantity of creative research results impossible otherwise.

One unique specimen in the program possesses substantially different isotopic compositions of organic and inorganic sulfur. Thus, researchers can determine



Using the new geologic workstation and mapping package, Beverly Seyler, geologist in the Oil and Gas Section, adds color to computer-generated subsurface geology maps of oil-producing sandstones in Edwards County. Her study is part of a new program to improve oil recovery from existing fields.

the source of the sulfur contained in products derived from this coal, i.e., whether the source is organic or inorganic. The sample has been used in several studies wherein the removal of organic sulfur had to be verified.

These ISGS research programs perhaps will help increase the utilization of Illinois coal and the state's limestone resources, preserve the Illinois coal market, and result in continued or even increased employment of miners. For every million tons of increased coal production, approximately 260 mining jobs would be created.

Researchers have initiated another project to determine the availability of coal resources in Illinois. While previous studies have identified 180 billion tons of coal "in the ground," improved assessments are necessary to identify those coal resources that are minable under existing geological, economic, environmental, technological and legal constraints. This project is part of a continuing effort to build a more accurate national data base on coal resources.

In cooperation with the USGS' National Coal Resources Data System, Survey scientists are examining the impacts of such factors as coal thickness and quality, overlying urban development, presence of closely spaced oil wells, and previous mining in underlying or overlying coal seams on the amount of coal that can actually be mined with present technology. Preliminary results from four regions of the state indicate that, in some cases, as little as 20 percent of the total coal known to be present can ultimately be extracted.

Turning to oil, a report by the U.S. Department of Energy (USDOE) identified the inadequate supply of domestic petroleum for transportation fuels as the most serious short- and long-term energy problem for the United States. Of major concern are the ongoing developments in the oil industry (especially the low price of oil) that have had a nation-wide impact on research efforts, domestic oil production and economic development in oil-producing states. Recently, imports temporarily exceeded 50 percent of the nation's supply of crude oil and petroleum products, costing the country about $40 billion a year and placing the United States in a steadily worsening economic position while increasing concerns for security of supplies. The Energy Information Agency and the Central Intelligence Agency have projected imports to exceed 50 percent of the country's supply by 1994.

Since 1852, when oil was discovered in Illinois, more than 3.4 billion barrels of this finite resource have been extracted. Although the state's production has generally declined since reaching its peak in 1939, the USDOE recently estimated that 1.5 billion barrels of oil, already discovered but left behind by past production techniques, remain in the ground in Illinois.

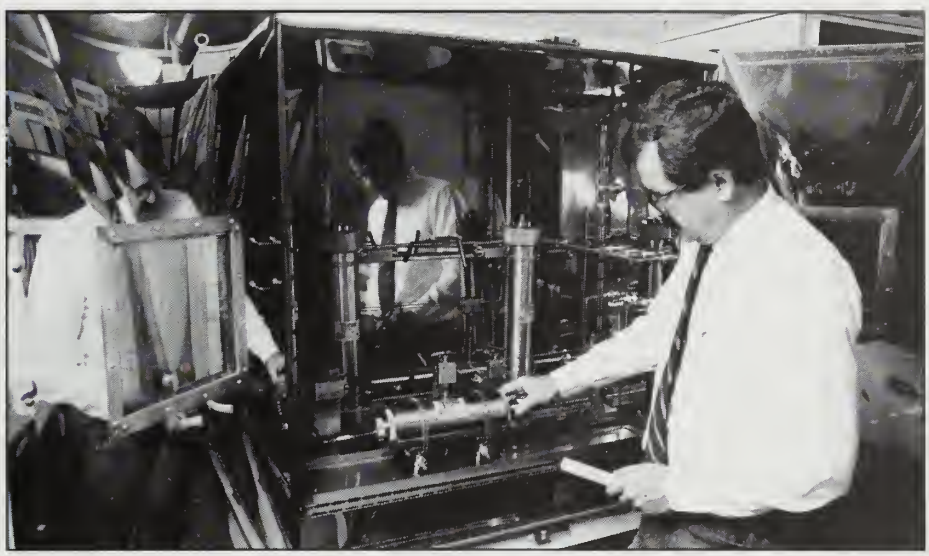
The ISGS is responding to the needs of the state and the nation by positioning itself to be of maximum assistance to Illinois' oil industry, especially to the independent producers who provide the stable base for the state's oil and gas operations. The Survey's expanded program of research and service in oil and gas has the goals of helping find economic means of obtaining more oil from the fields already discovered, providing new exploration ideas, identifying under-explored and new resources of oil and gas, and providing information about emerging ideas and developments for the oil industry.

On June 28, 1989, the USDOE awarded a $750,000 grant to ENR for the first 12 months of a four-year program at the ISGS. The state will match the federal

grants. These leveraged dollars will fund "Research on Improved and Enhanced Oil Recovery in Illinois through Reservoir Characterization," which will examine subsurface heterogeneities in the state's oil reservoirs. Initial matching state funds were used to purchase a Geologic Workstation and a mapping package.

To recover more oil from existing fields, a better understanding of the nature of Illinois' petroleum-producing reservoirs is necessary. Immediate research efforts are focusing on the geological characteristics of reservoir rocks such as variations in porosity caused by differences in the original depositional environment of the rocks and variations in type and distribution of clays within the pore spaces. Such variations, often not detected or considered in the discovery and development of older oil fields, can affect the location and producibility of petroleum reservoirs.

Along these lines, ISGS scientists, in a preliminary appraisal, have found, through statistical analysis of rock and fluid properties compiled by oil and gas reservoir and by field in Illinois, that the producing section of the McClosky can be divided into three distinct reservoir subgroups, whereas the Aux Vases and Cypress Sandstones can each be divided into two reservoir groups. Based on analysis of electric logs, reservoir quality in the Cypress Sandstone is largely dependent on the deltaic facies in which it was deposited. At least four distinct facies have been recognized from electric-log characteristics and, where possible, are being documented by comparison with core.... An initial understanding of oil production in the Cypress and Aux Vases reservoirs has developed from detailed, thin-section analyses of samples from these units coupled with core and electric-log char-



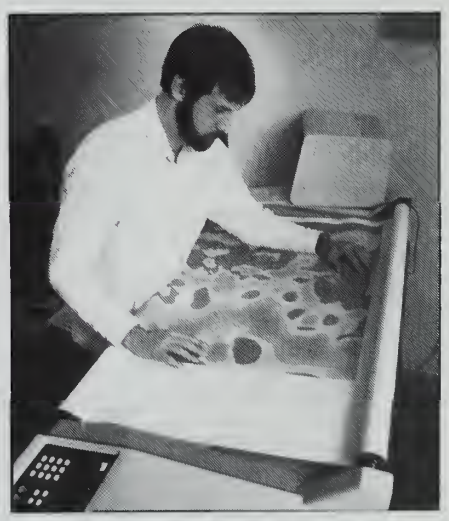
Donald Oltz, geologist and head of the Oil and Gas Section, demonstrates a core-test system used to study geological characteristics of oil-bearing reservoir rock to improve well-completion technology.

acteristics and clay-mineral distribution. Heterogeneities must be considered in well spacing, completion and stimulation practices. Heterogeneities in reservoir rocks restrict or seal off oil-flow paths. Description of reservoirs at this level requires the advanced technology available at the ISGS. Architectural and petrophysical modelling of outcrops and subsurface reservoirs improves the understanding of fluid-flow paths. Unswept or by-passed oil, remaining in reservoirs because of variations in geological conditions, is a promising exploitation target which could help the nation reduce its shortfall of domestic hydrocarbon production and assist Illinois' producers increase the state's oil production. By-passed mobile oil may exceed 1.5 billion barrels in Illinois.

New exploration ideas and concepts are being introduced to serve as incentives for industry to explore for and produce more Illinois oil and gas. In effect, the ISGS provides research for the smaller independent oil producers, who are unable to undertake research on their own, yet produce most of the state's oil and gas. For instance, Survey scientists have published a paper on the use of gravity surveying for locating Silurian reefs that are potential bearers of hydrocarbons. An example over the Marine Field in Madison County illustrates how measurement of the local gravity field can aid in this type of exploration. The study indicates that similar mapping techniques could be effective in locating buried Silurian reefs elsewhere in the Illinois Basin.

Lower Devonian oil fields in southwestern Illinois are controlled by a regional pinch-out of porous dolomite. Although several oil fields have been discovered along this trend, no geologic explanation for their occurrence has previously been published.... While hydrocarbon exploration has been sparse in southern Illinois—south of the Cottage Grove Fault System—review of the exploration potential for energy minerals in the area of the Shawnee National Forest (SNF) is timely because the U.S. Forest Service is now able to lease portions of the SNF. Geophysical, well-log, rock-sample and geochemical information are being integrated to determine factors important to the potential generation, migration and entrapment of hydrocarbons in the subsurface in southernmost Illinois.... To aid industry in the search for hydrocarbon traps, scientists are preparing an updated and revised version of the 1971 Paleogeologic Map of the Sub-Pennsylvanian Chesterian Surface in the Illinois Basin. Given knowledge of the location of paleovalleys, explorationists can better define the multiple plays associated with paleovalleys.

In hydrocarbon generation and migration studies, the ISGS is using gas



Steve Whitaker, geologist in the Oil and Gas Section, examines an oil field isopach map of Cypress Sandstone created with a new electrostatic plotter.

chromatography to correlate crude oils with source rocks in the Illinois Basin. Analysis of crude oils yielded "fingerprint" patterns which indicated that Illinois crude oils have at least two probable sources, one from the New Albany shale and one from an as yet unidentified Ordovician stratum.... Scientists are examining the chemical fingerprint patterns of the soluble organic fraction of shales from the Ordovician System and/or other older strata, comparing the patterns with those of Ordovician crude oils to search for possible genetic relationships between them. Shale samples from cores and cuttings from southern and southeastern Illinois are being processed for total organic carbon and Rock-Eval analyses.... Advanced computer modelling of the kinetic maturation of organic-rich sediments in Illinois also continues. These models are being coupled with conceptual ideas regarding the sources and timing of fluid emanations driving the migration of oil from source rocks to traps....

The state's 1988 oil production of 22,476,000 barrels had a value of more than $332 million. If applications of current technologies transferred by these research programs resulted in production of as little as four percent of the 1.5 billion barrels of mobile oil left in Illinois' reservoirs, at $20 a barrel, the value of that production could be as much as $1.2 billion. Any newly developed technologies will add incrementally to that figure.

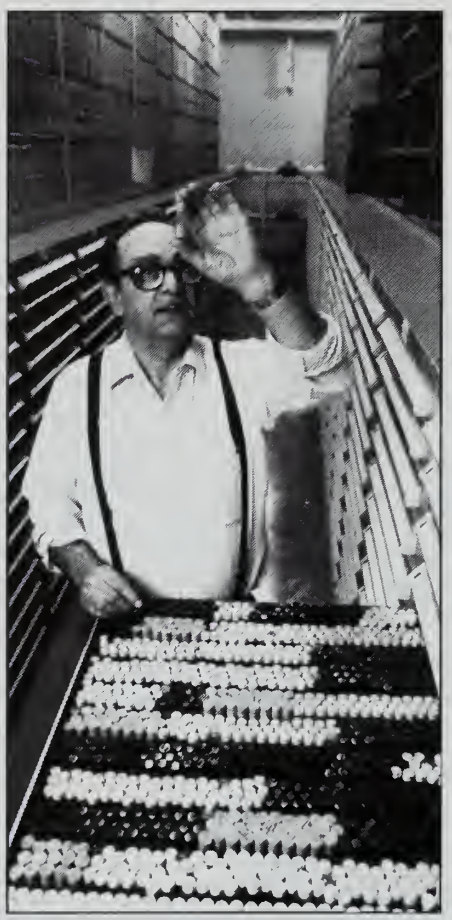
Need for Minerals

Industrialization requires increasingly larger quantities of minerals. The United States is significantly dependent on foreign sources for at least 20 strategic and critical minerals. A paper prepared on Strategic and Critical Minerals, defining them primarily in terms of supply vulnerability, concludes that only about a dozen strategic and critical minerals warrant being stockpiled. Four minerals—chromium, cobalt, manganese and platinum group metals—are the most strategic minerals. Titanium, tungsten, diamonds and graphite are also critical, but to a lesser extent. Geologic investigations are, therefore, required to assess the internal resource potential, to determine the long-term, world-wide availability of mineral commodities, and to provide essential perspectives on the impact of mineral extraction.

The values of extracted minerals in Illinois, including oil and coal, generally continued their downward trend in 1988, except for the industrial minerals industries, specifically sand and gravel and stone. (The decline in value was attributable primarily to a 6.9 percent drop in coal production, a 6.7 percent drop in oil production, and a 15 percent drop in oil prices.) Stone production rose by four percent, and sand and gravel production by eight percent, while prices for these minerals remained nearly unchanged. The total value of extracted minerals in 1988 was about $2.4 billion, down 8.5 percent from 1987. Including the overall inflation rate of about 4.5 percent, the decline in value in real terms for the year was about 13 percent.

While coal and oil are of recognized importance to continued industrial development, the present and future significance of the state's industrial minerals extraction and processing industries, including fluorite, limestone, dolostone, sand and gravel, barite, industrial sand, tripoli, clay and shale, may not be fully appreciated. These commodities and their products are essential raw materials for construction, manufacturing, agriculture and chemical processes: They are essential components of Illinois' infrastructure—its buildings, sewers, bridges and highways.

A continuing need exists for studies on the location, characterization, mode of origin, and potential uses of industrial mineral and metal commodities which will play an important role in rebuilding the infrastructure required for continued economic progress. Historically, the ISGS has engaged in research and provided information on industrial mineral and metal resources to industry, other state and federal agencies, landowners, and the general public. Recent projects reflect a new emphasis on regional resource assessments, responses to environmental problems, and improvements to mineral processing operations.



Harris McKinney, technician in the Geological Samples Library, pulls samples from a drawer containing insoluble residues.

The ISGS completed a series of maps of Cambrian and Ordovician carbonate rock units and a series of four cross sections depicting vertical and lateral changes in the Middle Mississippian limestones in Illinois as part of a cooperative project with the USGS and 11 other states on midcontinent strategic and critical minerals. This ongoing project is designed to assess the mineral potential of shallow basement and sedimentary sequences in the midcontinent area with special emphasis placed on the potential for carbonate-hosted metallic deposits.

In cooperation with the USGS and the Geological Surveys of the adjacent states, the mineral resource potential of the Paducah quadrangle, covering 7,500 square miles in southern Illinois, Kentucky, Indiana and Missouri, is being evaluated as part of the Conterminous U.S. Mineral Assessment Program (CUSMAP). The quadrangle includes significant active and inactive mining districts (fluorspar, lead, zinc and barite); extensive extraction of limestone, sand and gravel, silica and clay resources; active coal mines and producing oil fields.

This study includes compilation and evaluation of existing geological, geochemical and geophysical data for the region; geological mapping, geochemical analysis and geophysical measurements to expand the data and test new hypotheses; topical studies on the origin and development of mineral resources in the region, including coal, oil and gas, and both metallic and non-metallic ores; and appraisal of the potential for the discovery of additional mineral resour-

ces, based on the data gathered. The surficial geological map of the quadrangle is nearly completed. Also bedrock maps, cross sections, stratigraphic columns and text covering stratigraphy, structural geology and economic geology have been prepared for each of the four 1:100,000 quadrants that comprise the Paducah quadrangle. The ISGS is coordinating the research effort and data input from the states.

The CUSMAP study will result in the publication of new compilations of the potential coal, oil and gas, industrial minerals, and metallic mineral resources of the Paducah map region; detailed subsurface and surficial geological maps; and a series of reports on the geology and mineral resources of the area.

To gain a better understanding of the complex geology of the southern margin of the Illinois Basin, the ISGS, through the Cooperative Geologic Mapping Program (COGEOMAP) of the USGS, is mapping 16 7.5-minute quadrangles in great detail. Detailed mapping is changing geologic concepts of the region in ways that could provide new tools for successful oil and gas exploration. Faults outside the Illinois Fluorspar Mining District have been mapped in detail and are potential targets for mineral exploration. The first three geologic maps produced in the program were published in the summer of 1986. Three additional quadrangles have been mapped and are being edited for publication in 1990. Thereafter, about two quadrangles will be completed each year. The Illinois COGEOMAP program is an excellent example of successful cooperation between the federal and state Geological Surveys to address the pressing need for a national geologic mapping program, which will repay itself many times over in new resource discoveries, reduced construction and engineering costs, new businesses attracted, and geologic hazards avoided.

With the depletion of known resources and urban encroachment on undeveloped sites, the aggregate industry in the northeastern portion of the state faces an uncertain future, yet is vital to the construction industry. In this regard, the ISGS is identifying additional local sources of aggregate and helping quarry operators fully utilize existing resources through a better understanding of the local geology.

During the past year, 39 requests for information from quarry operators have been answered by Survey staff, who have been studying existing quarries and

As part of a project to locate sources of aggregates for the Chicago metropolitan area, Donald Mikulic, a geologist in the Industrial Minerals and Metals Section, examines rocks at Thornton Quarry.

An X-ray defraction instrument is used by Duane Moore, clay mineralogist in the Clay Minerals Unit, to analyze mineral composition.

exposures along with subsurface cores to provide a comprehensive data base on the geology of the study area. Along the same lines, an inventory is being made of active and abandoned quarry sites in Cook County. These data will be useful in locating new quarries, making plans for existing quarries, investigating potential environmental problems related to abandoned sites, and increasing the understanding of local geology.

Framework studies for specific stratigraphic intervals are also under way. For example, ISGS scientists have described 106 cores of Silurian rocks, from holes drilled in southern Cook County, representing 45,000 total feet of the section. Lithostratigraphic and biostratigraphic correlations of this material will provide a framework for the analysis of aggregate resources in the area. Results of the core logging have already led to discovery of Devonian-aged rocks at the bedrock surface along the Indiana border, descriptions of reef/inter-reef strata, and refinement of the Silurian stratigraphy for this part of Illinois.

The clay mineral laboratory continued to support a broad range of projects both within the ISGS and for others in Illinois seeking information. The laboratory, for example, identified materials stored at an abandoned hazardous waste site in Chicago as harmless, which reduced handling and disposal requirements of the IEPA.

Work has continued on the recovery of valuable materials from the waste streams of the silica processing plants of north central Illinois. For many years, these streams, containing kaolin clay and silica sand, have been impounded near the operating plants. Previous work showed that the sand and clay can be separated into two saleable products. Samples of the waste streams were collected over a period of time to obtain representative waste from current production. Clays, separated from the waste streams, met or exceeded standards for several types of clays that could have a value of approximately $64 per ton; the separated sand is typically clean, round-grain, fine sand of the type normally associated with the St. Peter Sandstone formation. Large quantities of this waste also are available.

Working together, ISGS mineral engineers and economists have devised three process-flow diagrams offering alternative designs for the recovery of fine coal currently being discarded by coal cleaning plants. An estimated 6,000,000 to 8,000,000 tons of fine material containing an average of 50 percent coal are deposited annually in slurry ponds in Illinois. The flow diagrams should assist operators in determining the economic feasibility of recovering the fine coal under their own plant conditions. Results indicate that fine wastes with a coal content as low as 11 to 13 percent could be economically recovered, and land savings from reduced need for slurry ponds could potentially be as high as 20 to 30 acres for the entire state per year.

A Directory of Mineral Producers in Illinois has been thoroughly revised. Being prepared for publication, the directory will provide a ready reference to producer names, locations and addresses, and major products.

Managing Water Resources

The assurance of the availability of water, a vital resource, is another issue facing the state as well as the nation. Besides being a necessity for all living things, water is a key to future economic growth. Since 1950, the use of water in this country has more than doubled. Where will future supplies come from? Information on location, quantity, quality

and use is essential to effectively manage water resources and predict the effects of future water development on the state's abundant, but often vulnerable, water supplies.

The ISGS organized and developed an automated groundwater data base, utilizing well records and other subsurface information on file at the Survey. The staff is working with the SWS and the USGS to develop a coordinated, compatible Groundwater Data Base for all potential users.

Buried bedrock valleys are important sources of groundwater throughout the state. A state-wide study is being conducted to define buried valleys in the bedrock surface and learn whether the valley-fill deposits may provide groundwater resources. To date, base maps have been prepared and data are being entered into a computerized data base.

Cheri Chenoweth, staff geologist in the Groundwater Resource Section, draws bedrock depth contours on a preliminary bedrock topography map. When completed, the map will provide data useful in locating bedrock valley aquifers.

The ISGS is also mapping total dissolved solids (TDS) content in groundwater. Water with TDS above 10,000 milligrams per liter is not considered to be treatable for use as drinking water. In a pilot study in Clay County, contoured maps and cross sections were prepared from analysis of electric logs to illustrate the distribution of groundwater, having estimated total dissolved solids concentrations of less than 3,000 milligrams per liter, between 3,000 and 10,000 milligrams per liter, and greater than 10,000 milligrams per liter. This phase of the study helped ascertain the methods to be used in other counties to determine the depths for each of these concentrations. The Department of Mines and Minerals (DMM) needs this information to regulate the depth to which oil producers must install surface casing in oil wells to protect the state's groundwater supplies. In the second phase, completed in April 1989, contoured maps were produced to show the distribution of groundwater in Crawford, Lawrence and Wabash counties for each of the three dissolved solids concentrations. Cross sections illustrating the relationship between stratigraphy and estimated water quality were prepared for each of the three counties.

Many communities in northeastern Illinois derive their water supplies from wells drilled into sandstone aquifers in the bedrock at depths of 500 to more than 2,000 feet. As communities have grown, more wells have been drilled, and groundwater withdrawals now greatly exceed the rate of recharge of the aquifers. As water levels in the wells have declined, pumping costs have increased. Furthermore, groundwater from these deep aquifers in the region centered around northern Kane County exceeds the USEPA's standards for barium content. Throughout much of northeastern Illinois, the deep groundwater also exceeds the standards for radium. A search for alternative, high-quality water supplies is mandatory.

The ISGS, working in cooperation with the SWS, has been studying the water

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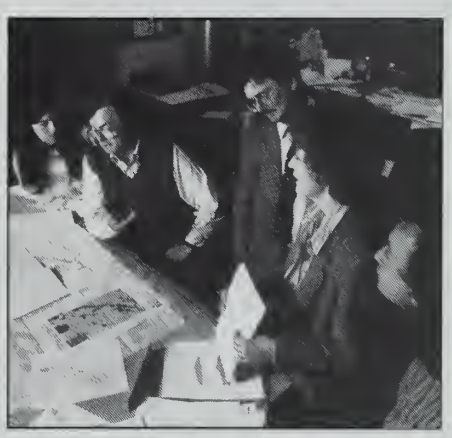
needs of northeastern Illinois for many years to assist local communities in water resource development. A three-year review and investigation of groundwater resources in the northern 35 counties of Illinois is being funded by ENR. Identification of potential groundwater resources will be useful to planners interested in new or increased water supplies. Base maps for the area were completed in February 1989. Entry of well-log data into a computerized data base was completed in June 1989. Draft maps of bedrock topography, drift thickness, and sand and gravel were completed in late June.

At present, the ISGS is completing projects to assist Kane County and its communities by using geophysical exploration techniques to search for shallow groundwater. New water supplies, with low contents of barium and radium, will reduce the quantities that must be pumped from the deep sources and, when blended, will bring the total water supply into safe tolerances for barium and radium. Successful shallow wells, supplying from 700 to 1,500 gallons per minute of low-radium and low-barium water, have been located for Aurora, Geneva, Montgomery and St. Charles. Other communities in that county receiving assistance include Batavia, Elburn, Elgin, Hampshire and South Elgin. The new groundwater resources have very low production costs in comparison to costs for pumping deep groundwater or importing water from Lake Michigan. Thus, the new water resources discovered by the ISGS will significantly decrease the cost of water production and improve the overall quality of the communities' water supplies.

In central Illinois, the ISGS is also working with the city of Bloomington to locate shallow groundwater resources to supplement surface-water supplies. To meet future demands, particularly during periods of low surface-water flow, groundwater is being sought in shallow sand and gravel aquifers.

Recently, shallow groundwater investigations have also indicated a relatively inexpensive way for Danville to meet future water demands. One successful well site, pump tested at 700 gallons per minute, has been located for that city. Other locations proposed for test drilling have been mapped by the ISGS. Development of Danville's groundwater resource is significantly less costly than expanding the surface-water reservoir.

To ensure high crop yields, farmers throughout Illinois are increasingly turning to irrigation. In some areas with especially sandy soils, irrigation is essential for crop production in drier years. Groundwater withdrawals by high-capacity wells (more than 100,000 gallons per day) have the potential to affect water



Working on the layout of a groundwater resources report are, from left, Pam Foster, artist; Nick Schneider, geologist and acting head of the Environmental Studies and Assessment Section; Brandon Curry, geologist, Quaternary Framework Studies Section; Ellen Wolf, coordinator of the Publications, Graphics and Photography Unit; and Mike Knapp, artist.

levels in nearby domestic wells. Provisions of the Water Use Act (WUA) of 1983 require the Geological and Water Surveys to provide technical assistance to Soil and Water Conservation Districts (SWCD) in assessing the potential impacts of new high-capacity wells. Amendments to the WUA in 1987 also require the Surveys to investigate complaints of insufficient water supply caused by high-capacity wells in parts of Iroquois, Kankakee, McLean and Tazewell counties.

To acquire more information on the shallow hydrogeology in Kankakee and Iroquois counties, where farmers are using more groundwater for irrigation, thereby causing seasonally declining water levels in the shallow dolomite bedrock aquifer and problems in some local wells, ISGS used geophysical methods for hydrogeologic mapping. Seismic refraction was used to map the bedrock surface, and electrical earth resistivity surveys and borehole geophysical surveys acquired new information to supplement data from existing well records on the nature of the glacial drift. This work will be helpful in addressing complaints filed under the WUA.

An ISGS staff member surveys the receding shoreline of this source of a community's water supply. The Groundwater Resources Section is working with Bloomington to locate shallow groundwater resources to supplement surface-water supplies. To meet future demands, groundwater is being sought in shallow sand and gravel aquifers.

Future Needs: Mapping Requirements Abound

The Illinois Basin covers approximately 60,000 square miles in the southern two-thirds of the state and adjacent parts of Indiana and Kentucky. Analysis of the stratigraphy and tectonic history of the basin contributes to the continued discovery and development of mineral resources. To advance their programs of research in basin analysis, the Geological Surveys of the three states have formed the Illinois Basin Consortium. The consortium will address geoscience problems and issues of a basin-wide nature through cooperative, integrated, multidisciplinary research projects.

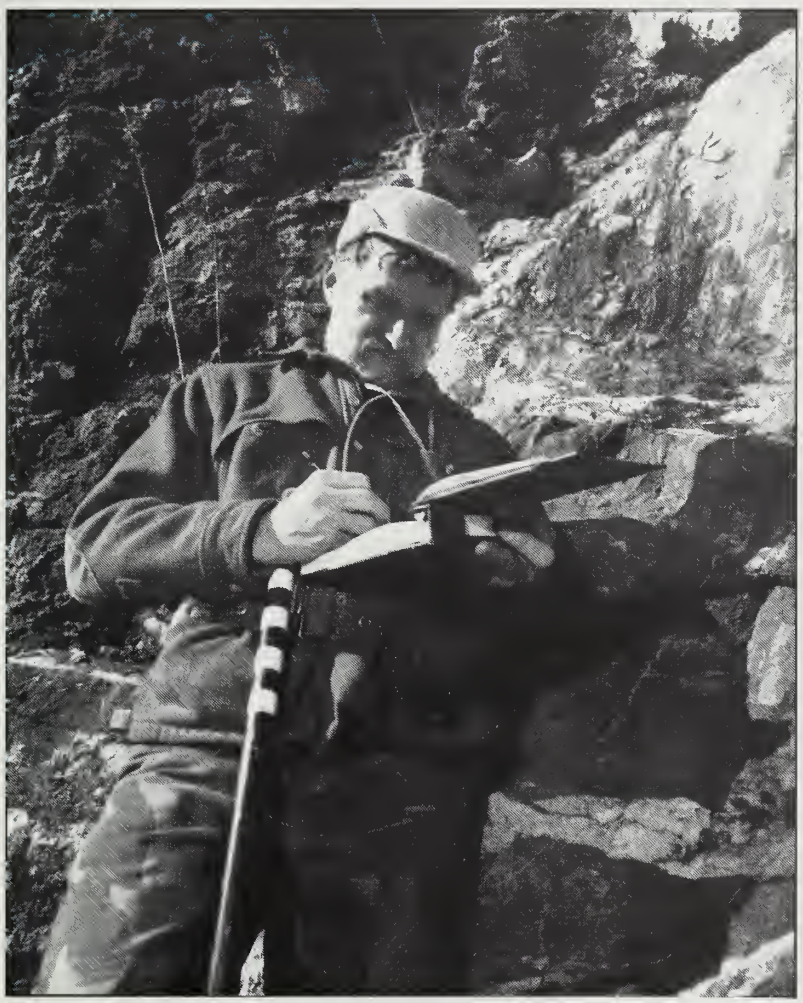
A grid of 20 regional cross sections has been planned to cover the Illinois Basin and provide framework for understanding the basin's tectonic and stratigraphic evolution, the controls on hydrocarbon migration and entrapment, and mineralization. Input on this program is being provided by members of the consortium.... An updated conodont (fossil) biostratigraphy has been formulated that provides for greater precision in correlating Upper Devonian rock units throughout the Illinois Basin....

The basin-wide efforts will provide a framework for more detailed studies needed to address environmental- and resource-related issues that face the state at regional and local levels. Detailed geologic maps and other studies of regions, counties or smaller units provide state and regional planners, county boards, public health departments and citizens with the information about the earth's surface and the materials that lie beneath it required to sustain economic development and protect the environment.

Almost every area of the state faces problems with waste disposal, groundwater protection, and the environmental effects of normal human activities. Detailed geological information is required to ensure maximum protection from possible contamination of sensitive groundwater and surface water supplies; to ensure that major highways, railroads, factories, schools and other facilities are constructed in sites that provide adequate support for foundations and are free of threats from flooding, landslides and other man-caused and natural earth hazards; and to guide officials in deciding the direction of future economic development. Geological and geotechnical considerations, for example, were among the significant factors in selecting the site for Diamond Star Motors' plant at Bloomington-Normal.

Although much is known about the geology of Illinois at state-wide and regional scales, "detailed" geological maps are available for only a few limited areas of the state. With the legislation requiring all counties to develop a solid waste management plan by 1995 and mandates of the IGPA, county boards, regional planning commissions, and local governmental entities are recognizing the utility and cost-effectiveness of detailed information about their local geology and mineral resources when making land-use and other policy decisions. Unfortunately, the detailed geological information generally is not available.

To provide the necessary geologic information to cover these state and regional concerns, the ISGS is undertaking a state-wide program of detailed geological mapping. Representatives from state and local governmental agencies, environmental groups, the mineral production and user industries, universities and professional organizations have formed



John Nelson, geologist in the Coal Section, takes field notes preparatory to making a detailed geologic map.

an Illinois Geological Mapping Advisory Committee to assist the ISGS in selecting areas to be mapped and the appropriate scales and types of maps to produce.

Under this mapping program, each county or region would be geologically mapped from the land surface down to and including the bedrock surface at a scale no smaller than 1:100,000, using the latest mapping and analytical techniques, to provide detailed information about the surficial deposits which most directly affect and are affected by human activities. Existing drill-hole records, infill exploratory drilling, and seismic reflection and refraction profiles will be used to determine the thickness and character of units not visible at the surface, locate potential aquifers, provide control for a network of cross sections used to illustrate the geology and test the distribution of geologic units predicted by the geologists' interpretations as well as to sample and map the rocks exposed at the bedrock surface.

During FY 1989, the ISGS expended approximately $424,000 for various kinds of geologic mapping projects in the state. In the future, federal funds for a national cooperative geological mapping program, now in the planning stage at the USGS, may provide a dollar-for-dollar match for state funds of as much as $1 million per year.

This type of geologic mapping can have a good rate of return. For example, in a $23-million program supported by state and federal funds over about 18 years, the Commonwealth of Kentucky cooperated with the USGS to complete detailed geologic maps of the entire state. Kentucky and the USGS officials estimate that the cost of the mapping program has been repaid 50 times over through new resource discoveries, reduced construction and engineering costs, new businesses attracted, and

geologic hazards avoided. A similar cost-benefit ratio might be expected in Illinois.

Since its founding in 1905, the Geological Survey has been mandated to operate a cooperative mapping program with the USGS to prepare topographic and other maps of the state. This cooperative topographic mapping program has attempted to provide modern, precise, cartographic information consistent with the needs of the state and compatible with national standards.

The basic building block of the cartographic program is the 1:24,000-scale, 7.5-minute topographic quadrangle map. All maps produced at smaller scales use the data from the 7.5-minute series. To cover the entire state, 1,071 of these quadrangles are required. While mapping at this scale began nearly 50 years ago in Illinois, the final quadrangle was not published until late 1987.

Printed maps age and no longer correctly represent an area because new roads, schools and churches are built; towns expand boundaries; paths of drainage ditches are altered; railroad rights of way are abandoned, thereby altering the shape of the landscape. Remapping is required to ensure that maps remain reasonably accurate for planning, engineering and recreational uses. Those more than 20 years old are generally regarded as unreliable for accurate planning and engineering purposes. Of the 1,071 topographic quadrangle maps, 408 are more than 20 years old, of which 22 are between 40 and 49 years of age. To ensure that the primary mapping base in Illinois remains less than 20 years old, 55 maps in the series must be revised annually. Current appropriations to the ISGS for the cooperative topographic mapping program are approximately one-sixth of the amount required to maintain a 20-year schedule of revisions.

While some groundwater information is available on a state-wide scale, detailed information for most of the state is unavailable to help local and regional officials make wise decisions regarding land use, groundwater resource availability, and groundwater protection. State agencies such as the IEPA, the IDOA and the Department of Public Health (IDPH) also require more detailed groundwater information to perform their regulatory functions. These decision makers need to know where groundwater is moving, where the recharge areas are located, and what natural protection exists for this resource. In addition, to establish wellhead and recharge-area protection zones, as required by the IGPA, more local- and county-scale information is needed.

Legislative mandates of the IGPA require the Surveys to conduct a technical assistance and research program that includes groundwater mapping and assessments, a groundwater monitoring network, a data collection and automation program, an evaluation of pesticide impacts on groundwater, and other basic and applied research. In addition, the two Surveys are to provide technical support to regulatory agencies to enable them to effectively perform their tasks mandated by both the IGPA and WUA.

The ISGS is anxious to focus on the basic, scale-dependent, groundwater-related questions that provide meaningful problem-solving answers to policy makers. Long-term benefits will accrue from maps providing information at the correct scale. For instance, more detailed studies of the hydrogeologic framework at regional and local scales will provide methods, principles, and background information that can be transferred to other areas of the state. This new knowledge, expressed at appropriate scale, will provide regulatory

agencies and local governments with the necessary data to make informed land-use decisions, resulting in fewer costly groundwater clean-up efforts later and assuring a protected groundwater supply for future generations.

While the Surveys have already mapped priority recharge areas on a state-wide scale to guide the IEPA in establishing groundwater protection planning regions, new efforts are needed to locate groundwater resources, delineate aquifers, assess base-line groundwater quality, evaluate the hydrologic properties of geologic materials, determine aquifer recharge areas and flow patterns, and assess groundwater protection strategies. This information at the local level will determine the water-yielding characteristics of aquifers, the suitability of water quality for various uses, the degree of vulnerability of the aquifer to contamination, and the necessity for stringent contamination control.

The Surveys are the repository for groundwater data provided by state agencies, industries and private individuals. A computerized system must be developed to integrate the data bases and provide for storage, retrieval, analysis, and display of Illinois groundwater information such as groundwater monitoring results, well logs, pollution source permits, and water quality assessments. Such an extensive hydrogeologic data base would be useful to policy makers and researchers by facilitating information exchange and coordination of groundwater protection programs.

Plans call for incorporating into this data base the new information gathered as part of programs on pesticide monitoring and state-wide monitoring. Results of the current pesticide pilot study will be used to refine a plan for a state-wide survey of pesticide effects on groundwater quality.

Plans also call for providing technical services under the mandates of the WUA and to retire a backlog of water-use impact reviews and water-supply interruption investigations. Then efforts can be directed toward collecting and developing local-scale and specific information on the geology and hydrology of the legislatively-targeted counties.

Illinois' mapping needs are heavy. To tackle these needs, the Survey envisions state-wide planning of involved planners, engineers, consultants, researchers and governmental officials who require more detailed information about earth materials on a regional and local level. State-wide mapping can then be done on a prioritized basis to solve resource and environmental problems and concerns and make wise land-use decisions. More site-specific data will be developed to manage and protect the state's natural resources—energy-related resources, industrial and metallic minerals, and groundwater. So much depends on adequately mapping Illinois' future.

The speed and degree to which these plans are met are dependent on levels of funding. Legislation has been put in place that can be very effective. Infrastructure is also in place to carry out the effort. Possessing the background and experience to implement the assigned mandates of these new laws, the Scientific Surveys await only the fiscal resources to handle the tasks at an effective level and on a timely basis—goals envisioned both by the Survey and the General Assembly. Together we stand ready to further address the state's issues of water, land, energy, mineral resources, environmental protection, waste management, hazards reduction and recreational pursuits—issues that are of vital concern to all citizens of Illinois.

Research Projects in Fiscal Year 1989

The map of Illinois, printed on the following two pages, shows counties for which research results were published or where research was in progress during Fiscal Year 1989 (June 1988-July 1989). For each of the three research groups—Mineral Resources and Engineering, Environmental Geology and Geochemistry, and General and Basic Research—programmatic areas have been identified and numbered in the map's legend.

To obtain complete coverage of the Survey's research and service efforts for the year or additional information about the various research projects being carried out across the state, please write or call the ISGS (217/333-4747) and request a copy of the Annual Report, which will be supplied free of charge. If you are interested in maps and other publications of the ISGS, request a copy of the "List of Publications," for which there is also no charge.

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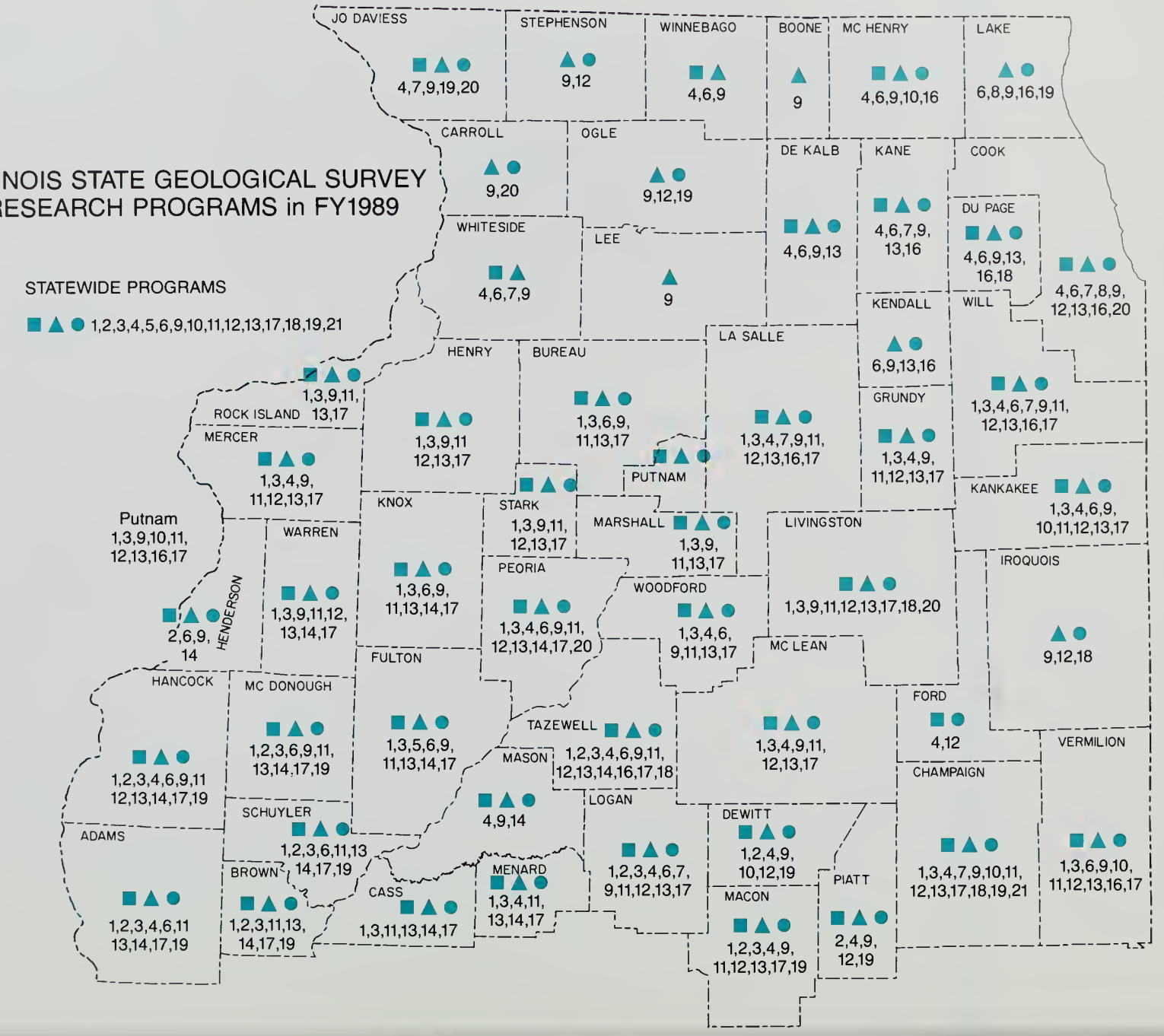
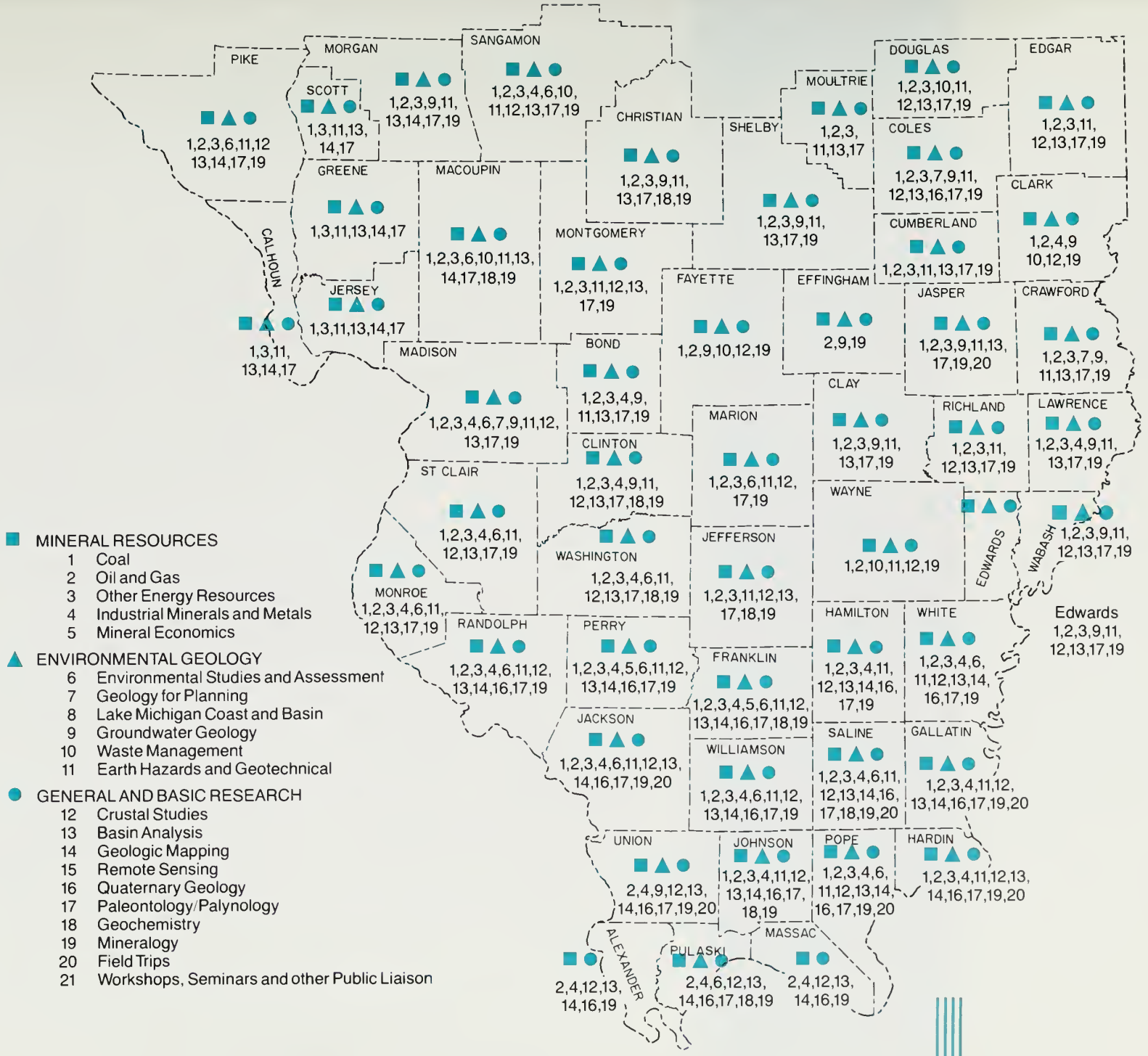
ILLINOIS STATE GEOLOGICAL SURVEY RESEARCH PROGRAMS in FY1989





■ MINERAL RESOURCES
- 1 Coal
- 2 Oil and Gas
- 3 Other Energy Resources
- 4 Industrial Minerals and Metals
- 5 Mineral Economics

▲ ENVIRONMENTAL GEOLOGY
- 6 Environmental Studies and Assessment
- 7 Geology for Planning
- 8 Lake Michigan Coast and Basin
- 9 Groundwater Geology
- 10 Waste Management
- 11 Earth Hazards and Geotechnical

● GENERAL AND BASIC RESEARCH
- 12 Crustal Studies
- 13 Basin Analysis
- 14 Geologic Mapping
- 15 Remote Sensing
- 16 Quaternary Geology
- 17 Paleontology/Palynology
- 18 Geochemistry
- 19 Mineralogy
- 20 Field Trips
- 21 Workshops, Seminars and other Public Liaison

Writer/Editor: Sue Muckensturm
Graphic Designers: Sandra Stecyk, Pam Foster
Photographer: Joel Dexter

Printed by authority of the State of Illinois/1990/2000